NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY

JOSEPH HYDE PRATT, State Geologist

ECONOMIC PAPER No. 46

THE VEGETATION OF SHACKLEFORD BANK

BY

I. F. LEWIS

RALEIGH
EDWARDS & BROUGHTON PRINTING CO.
STATE PRINTERS
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LETTER OF TRANSMITTAL

Chapel Hill, N. C., June 1, 1917.

To His Excellency, Honorable T. W. Bickett,
Governor of North Carolina.

Sir: I have the honor to submit herewith for publication as Economic Paper No. 46 a report on "The Vegetation of Shackleford Bank" by Mr. I. F. Lewis.

Respectfully,

Joseph Hyde Pratt,
State Geologist.

PREFACE

It has been the policy of the North Carolina Geological and Economic Survey to publish, as opportunity offered and printing funds were available, a series of reports relating to the natural history of the State.

In connection with his work at the United States Fisheries Biological Station at Beaufort, North Carolina, Mr. I. F. Lewis has made a study of the vegetation of Shackleford Banks, and it is believed that the results of this investigation will be of value not only in connection with the conservation of land areas along the coast, but will add much to the other botanical studies of the State.

In this as well as in numerous other investigations, we have had the coöperation of the United States Bureau of Fisheries.

It is expected that this report will lead to other investigations which will add more and more to the botanical history of the State.

JOSEPH HYDE PRATT,
State Geologist.

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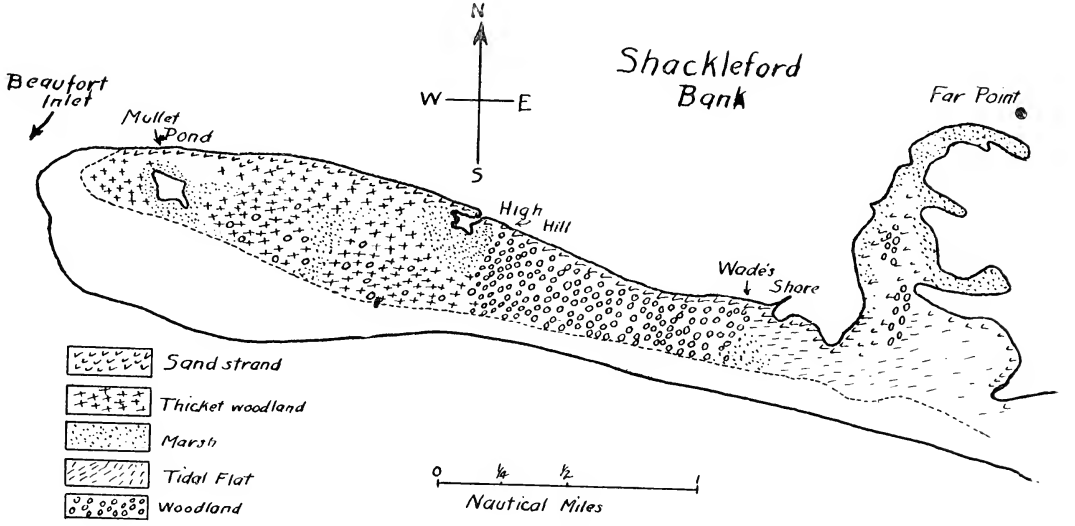


Detailed Sketch of Shackleford Bank

THE VEGETATION OF SHACKLEFORD BANK

By I. F. Lewis.

INTRODUCTION

Shackleford Bank is the strip of land extending from Cape Lookout on the east to Beaufort Inlet on the west. It is about eight miles long and, on an average, half a mile broad. On the south it is bounded by the Atlantic Ocean, on the north by Bogue Sound. Together with Core Bank, with which it is continuous, it forms a long link in the chain of sand reefs bordering the southeastern coast of the United States.

GEOLOGY

Evidence has recently been brought forward by Cobb[1] to show that this long sand reef is essentially a part of the mainland, and that the adjoining sound may be regarded as the estuary of a river which was formerly "a southern tributary of the large river made up of the Pamlico and the Neuse."

SOILS

The soils of Shackleford may be classified under three heads: (*a*) A fine white marine sand, with little or no humus, is found on the outer beach, the dunes, and in places bordering the sound. (*b*) A gray sandy loam in the elevated central portion of the Bank. The quantity of humus in the soil varies. In places it is slight in amount, but usually it is present in sufficient quantities to form a good garden soil, capable of supporting a luxuriant vegetation. (*c*) In the marshes on the sound side of the bank a black mud, 1 to 2 feet deep, is found overlying a sandy substratum.

The soil water is usually 18 inches or less below the surface, and, with the exception noted below, uniformly fresh. Even where the tides cover the marshes, and water standing on the surface is salt, with a specific gravity of 1.023, the soil water is fresh. In this case the ground water probably comes up from below through the sand, the soil being too impervious to allow the surface salt water to percolate through to the fresh water below. Only in the Spartina-Salicornia marshes, which are constantly wet with salt water, is the ground water not fresh. Wherever plants other than *Spartina glabra* (*stricta*), *Salicornia spp.* or *Borrichia frutescens* grow, the ground water is fresh.

[1]Notes on the Geology of Core Bank, N. C.: Journal of the Elisha Mitchell Scientific Society, Vol. 23, No. 1. 1907.

PHYSIOGRAPHY

The elevation of Shackleford varies from sea-level in the marshes to 20-25 feet in the higher ground of the interior. Toward Cape Lookout Light are some shifting dunes perhaps 35 or 40 feet high.

The physiographic conditions on Shackleford are causing rapid changes in the vegetation of the Bank, which will be referred to later. At present it is sufficient to state that the sand of the beach is advancing on the forest at a comparatively rapid rate, destroying the vegetation in its path.

CLIMATE

The climate of Shackleford is very similar to that of Hatteras, described by Kearney.[1] From data furnished by the United States Weather Bureau for Beaufort (2 miles from Shackleford) and Hatteras, the following points of difference are taken:

The annual mean temperature of Beaufort for the last six years is 63.6° F. (17.5° C.), while that for Hatteras for the same period is 62.3° F. (16.8° C.). The maximum summer temperature of Beaufort is slightly higher (about 3° F.) than that of Hatteras, while the minimum winter temperature is slightly lower. There are practically no days at either place when the temperature does not rise as high as 43° F. (6° C.).

The latest killing frost in spring, and the earliest in autumn, occur at about the same time in both places (February 25 and December 13).

The amount of sunshine during the year is less at Beaufort than at Hatteras. At Beaufort the average number of rainy days during the year is 128, clear days 117, as against 118 and 204 for Hatteras. The intensity of light is greatly increased at both places by reflection from the water and the white sand, so that the actual amount of light available for the use of plants is greater than at an inland station with the same number of sunshiny days.

No data are available for determining the atmospheric humidity. The prevailing wind during the growing season is from the southwest, and is laden with moisture from the Gulf Stream, so that the average humidity is probably not less than at Hatteras, where it is notably high.

The annual rainfall is even greater at Beaufort than at Hatteras. During the years 1896-97-98 and 1906-07-08 (the only years for which data on this point are available for both stations) the average annual precipitation at Beaufort was 58.59 inches, at Hatteras 53.12 inches. However, the estimated mean annual precipitation is greater for Hat-

[1]Kearney: The Plant Covering of Ocracoke Island; Contributions from the U. S. Nat. Herb., Vol. 5, No. 5. 1900.

A. Portion of the outer beach, showing a small dune built up by *Uniola paniculata*. Around it are remnants of a destroyed forest

B. The stable barrier dune of the outer beach on Bogue Bank, formed by *Uniola paniculata*. (Photograph by R. E. Coker)

teras than for Beaufort (Hatteras 60.85 inches, Beaufort 52.55 inches).[1] These figures differ somewhat from those quoted by Kearney for Hatteras.

The precipitation is fairly uniform throughout the year. No prolonged period of drought is liable to occur.

The prevailing wind during the growing season is from the southwest. This is the wind which most affects the woody vegetation, so that the trees in exposed positions incline strongly to the northeast, the windward (southwest) side being denuded of branches, while the foliage lies mainly to leeward of the axis. Just the opposite is reported for the trees on Ocracoke.[2]

NOMENCLATURE

The nomenclature adopted is that of Gray's Manual of Botany, 7th edition, revised by Robinson and Fernald, and in the case of plants not listed in this work, of Small's Southern Flora.

Exact determination of the plants found is of the highest importance in such an account as this. This has been made possible by the kindness of Dr. John K. Small, of the New York Botanical Garden, to whom specimens of practically all the plants listed were sent. I wish to express here my thanks to Dr. Small for his assistance.

PLANT FORMATIONS

The plants occurring on Shackleford Bank may be arranged in the following groups:

I. Sand strand vegetation.
   1. Treeless (open):
      a. Inner beach formation: *Croton-Cenchrus* association.
      b. Outer beach formation: *Salsola-Euphorbia* association.
      c. Dune formation: *Uniola paniculata* association.
   2. Trees and shrubs (closed):
      a. Thicket formation: *Ilex vomitoria* association.
      b. Thicket woodland formation: *Persea-Callicarpa* association.
      c. Woodland formation: *Quercus virginiana* association.

II. Marsh vegetation.
   1. Salt marsh formation (closed): *Spartina-Salicornia* association.
   2. Creek marsh formation (closed): *Juncus-Elecocharis* association.
   3. Dune marsh formation:
      a. Cladium-Kosteletzkya association.
      b. Proserpinaca-Aspidium association.

[1] From Annual Summary, N. C. Section of Climatological Service of the U. S. Weather Bureau, 1908, p. 105.

[2] Kearney, l. c., pp. 266, 271. I am informed by Mr. W. B. Longest of Beaufort, who has visited Ocracoke daily for some years, that Kearney is in error as to this matter. Mr. Longest states that at Ocracoke, as elsewhere on our coast, the trees are most affected by the summer winds (off the sea), and that the axes of the trees incline toward the North.

c. Isnardia-Pluchea association.
d. Acorus-Salix association.
4. Tidal flat formation (closed): *Scirpus-Paspalum* association.

I. Sand strand vegetation.

1. Treeless (open).

a. Inner beach formation.

This formation fringes the sound side of Shackleford except in a few places where the salt marsh extends to the water's edge. The soil is a fine sand, bare of vegetation up to the limits of mean high tide. Above this limit *Spartina patens, Cenchrus tribuloides,* and *Croton maritimus,* all perennial species, occur commonly, though not covering the ground completely. *Chenopodium Botrys, Physalis viscosa,* and *Salsola Kali* are of common, though not universal, occurrence.

b. Outer beach formation.

The sandy soil is mixed with broken fragments of shells. The soil water stands at a depth of about 12 inches, and is fresh. The outer beach is overrun by the highest winter tides, but is above the mean high-tide line.

The vegetation is sparse and open, the individual plants standing at wide intervals. The loose character of the soil imparts a desert aspect to the vegetation. *Salsola Kali, Euphorbia polygonifolia,* and *Amaranthus pumilus* are characteristic of this formation. *Fimbristylis castanea* and *Spartina juncea* (*patens*) occur occasionally.

c. Dune formation.

The sand accumulated on the dunes is wind-blown and of fine texture. The soil water is fresh and stands at a depth of 18-24 inches.

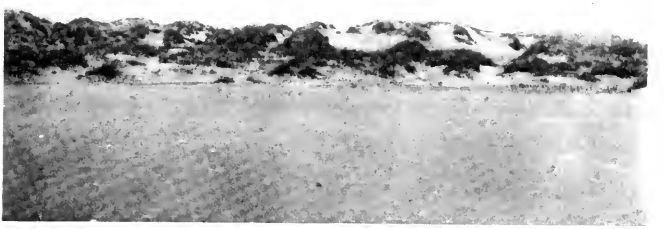
The dunes are covered with *Uniola paniculata,* whose flowering stalks, sent up in abundance, are very striking. This species appears to set seed rarely in this locality. Besides the Uniola, *Physalis viscosa, Croton punctatus, Solidago sempervirens,* and *Oenothera humifusa* are present. This formation reaches its best development on the neighboring Bogue Bank. (See Plates II *A* and *B* and Plate III *A*.)

2. Trees and shrubs.

a. Thicket formation.

The soil is sandy, with a slight admixture of humus. Owing to its being completely shaded, it dries out much less readily than the open sandy soil of the preceding formations.

Ilex vomitoria, from a few inches to 3 feet high, covers the ground so closely that one can with difficulty make his way through the thickets. Where a break occurs in the vegetation, *Ilex opaca, Juniperus virginiana, Smilax Bona-nox, Myrica caroliniensis,* and other species occur.



A. Face view of the barrier dune on Bogue Bank

B. View of thicket woodland and marsh, taken from the sand wall

b. Thicket woodland formation.

The soil here is a light sandy loam. The vegetation is very dense and consists of a large number of species of trees, shrubs, herbs, and woody vines. The trees commonly occurring are *Persea pubescens, Quercus nigra, Osmanthus americanus, Pinus taeda,* and *Juniperus virginiana.* Of shrubs the most striking are *Ilex vomitoria, Myrica cerifera, Callicarpa americana, Ilex glabra,* and *Sabal glabra.* Characteristic herbs are *Asplenium platyneuron, Anychistrum Baldwinii, Lechea villosa, Hieracium Gronovii, Elephantopus nudatus, Acalypha gracilens, Ascyrum hypericoides, Galactia volubilis, Desmodium paniculatum,* and species of *Panicum.* Woody vines are very conspicuous. *Berchemia scandens, Smilax Bona-nox, S. laurifolia, Vitis rotundifolia,* and *Psedera (Parthenocissus) quinquefolia* are most abundant. (See Plate III *B* and Plate IV *A* and *B.*)

c. Woodland formation.

On all the higher parts of the island except the dunes, the soil is a deep light sandy loam. On this trees reach a considerable size. The vegetation is much less dense than that of the previously described thicket woodland. Common trees are *Quercus virginiana, Carpinus caroliniana, Ilex opaca, Morus rubra,* and *Quercus phellos (laurifolia).* *Ilex vomitoria* and *Zanthoxylum Clava-Herculis* occur commonly as well developed shrubs. The characteristic herbs are *Stipa avenacea, Uniola laxa, Jatropha stimulosa,* and *Eustachys petraea.* Woody vines, while of common occurence, are less conspicuous than in the thicket woodland formation. (See Plate V *A.*)

II. Marsh vegetation.

1. Salt marsh formation.

This formation occurs commonly along the border of the sound. The soil is a blackish mud about 2 feet deep, very impenetrable to surface water. The surface is usually covered with salt water at high tide, yet the soil water, about 12 inches below the surface, may remain perfectly fresh.

The only plants occurring always in this formation are *Spartina glabra (stricta), Salicornia ambigua,* and occasionally *Borrichia frutescens.* At one point opposite Cape Lookout *Salicornia mucronata (Bigelowii)* replaces the elsewhere universal *S. ambigua.* On the next Bank to the north, Ocracoke Island, Kearney[1] reports, in a similar formation, *Salicornia europaea (herbacea)* associated with *Spartina stricta (glabra).* (See Plate V *B.*)

[1]Kearney, l. c.

2. Creek marsh formation.

The conditions of soil and soil water are the same as in the preceding formation. The creek-marsh formation is not, however, covered at mean high tide.

The characteristic plants of this formation are *Juncus Roemerianus*, *Scutera palustris*, and *Eleocharis albida*. Abundant are *Scirpus americanus*, *Gerardia maritima*, *Fimbristylis castanea*. (See Plate VI *A* and *B*.)

3. Dune marsh formation.

The soil is dark as in the salt marsh formation, but is not reached even by winter high tides and the surface water is therefore fresh.

a. Where the drainage is good, the surface water running into small creeks which make their way to the sound, occurs a rich plant covering characteristic of which are *Cladium jamaicense*, *Kosteletzkya virginica;* abundant are *Boehmeria cylindrica*, *Cyperus strigosus*, *Ipomoea sagittata*, *Lippia nodiflora*, *Bacopa Monnieva*, (*Monniera Monniera*), *Ammania Koehnii*, *Dichromena colorata*.

b. Where the marsh is inclosed on all sides by neighboring high ground, the drainage is very poor. As already mentioned, the black soil is very impenetrable, and the surface water stands almost indefinitely, becoming dark brown in color. Here *Ludvigia palustris*, *Pluchea foetida*, *P. camphorata*, and *Cyperus haspan* are the characteristic species.

c. In a few places such a poorly drained area seems liable to be covered by the highest winter tides. Here *Proserpinaca pectinata* and *Aspidium Thelypteris* dominate the vegetation.

d. In the lee of the highest dunes near the eastern end of the Bank are permanent pools (1-3 feet deep) where *Acorus Calamus* and *Salix* sp. are common. Around these pools occur many of the species noted above. (See Plate VII *A* and *B*.)

4. Tidal flat formation.

This occurs wherever an area originally occupied by the dune marsh has become sanded over. The soil is a mixture of the mud of the swamp and the sand which has drifted in. The characteristic association is made up of dwarfed *Scirpus americanus*, 6-8 inches high, and of *Paspalum distichum*. *Fimbristylis castanea* and *Spartina patens* are often met with. All of these are plants at home in the marshes. Besides them, *Euphorbia polygonifolia* and *Cenchrus tribuloides* occur as invaders from the sand strand.

A. Thicket woodland. The trees, *Juniperus virginiana*, and the woody vines, *Berchemia scandens*

B. Dune marsh and thicket woodland

GENERAL ACCOUNT OF SHACKLEFORD VEGETATION

The western end of the island presents a sandy shore both to the sea and to the sound. The sand strand vegetation on the sound side is formed of scattered specimens, only a few species being represented. The most characteristic are *Spartina patens*, *Cenchrus tribuloides*, and *Croton punctatus*. About twenty other species, both annual and perennial, occur occasionally or commonly with these. The majority are either halophytic or pronouncedly xerophytic. The vegetation, like that of the outer beach, is desert-like and unattractive.

Leaving the sound, the strand rises a few feet and passes into the higher ground in the center of the Bank. Here the knolls, of loose sandy texture, are occupied by a thicket vegetation, while in the hollows are swampy areas, with the soil black mud, on which flourishes a luxuriant herbaceous vegetation.

Passing through this area toward the sea one comes on an advancing sand wall, 10 to 20 feet high, which is burying the vegetation at a rapid rate.[1] On the sandy plateau south of this some cedars still stand, the alburnum eaten away by the driving sand, the heart-wood sound. Some of these trees have been uprooted and lie almost completely buried. Others are upright, the topmost branches alone showing above the sand. On those dead cedars which are not covered by the sand are frequently to be found masses of lianas, their leafy crowns replacing those of the dead trees exactly, so that in the distance the trees seem to be living. One such dead Juniperus bore five lianas, forming a dense mat where the crown of the tree was, and rooting in the sand. The soil water at this point was 18 inches below the surface and quite fresh. The usual woody vines growing on these outposts of vegetation are *Psedera* (*Parthenocissus*) *quinquefolia*, *Vitis rotundifolia*, *Cissus arborea*, *Rhus radicans*, and *Berchemia scandens*.

Besides these remnants of a once vigorous forest growth, there are present on the sandy plateau between the thickets and the sea only a few scattered specimens of the species usual on the outer beach. The shifting soil is no doubt responsible for the sparseness of living vegetation in this portion of the island. At one point, near the western end, a few small dunes have been built up by the growth of the sea oats (*Uniola*.)[2] The dunes are low and dome-shaped. Since they are isolated from one another, they do not form a barrier between the outer sand and the inner thickets, as is the case on the neighboring Bogue Bank.[3] They are growing and spreading, however, and in time, if left undisturbed, will afford some protection to the vegetation at this end of the Bank.

[1] Figs. 4, 6, 11, 12.
[2] Fig. 1.
[3] Figs. 2, 3.

The interior of this portion of the island is covered by a very dense vegetation, through which it is difficult to force a passage. The lower ground possesses a black, impervious soil, constantly wet with rain-water, and covered by a dense herbaceous growth. Around these fresh-water swamps the sandy elevations are covered with shrubs and small trees.[1] Woody vines are especially abundant here, growing with a tropical luxuriance which contrasts strangely with the desert-like aspect of the beach formations.[2]

Between High Hill and Mullet Pond (see map) the sound is bordered by salt marshes, which are overflowed at high tide. The vegetation here is constant in character and appearance. A dense stand of *Spartina glabra*, in which *Salicornia ambigua* is abundant, gives the marshes a uniform grassy appearance. This association is invaded rarely, and then only by *Borrichia frutescens*.

Above the level of ordinary high tides the marsh is given a more varied aspect by the presence of a number of invading species. Of these, *Juncus Roemerianus* is one of the first to appear. This is a large, tall rush, the dark clumps of which dot the marshes here and there. Climbing on the rush is usually to be found a narrow-leaved, slender herb, *Scutera palustris*. Between the hummocks of *Juncus* occurs commonly *Gerardia maritima*, forming purple patches on the level swamp.

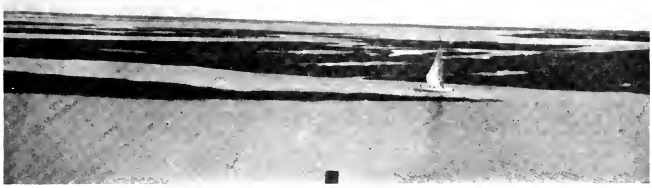
East of High Hill the ground is uniformly high, from 10 to 20 feet above sea-level, and the sand strand is quite narrow. In this stretch occurs open woodland, where the vegetation is not so dense as in the thicket woodland farther west. The characteristic trees are *Quercus virginiana*, *Q. phellos*, *Persea pubescens*, *Morus rubra*, and *Ilex opaca*. While some of these trees are of considerable size, none of them attain the dimensions of the same species on the less exposed mainland. Between them *Ilex vomitoria* (yaupon) is the usual shrub, here being beset with numerous short thorn-like branches. Woody vines are conspicuous, the species being identical with those mentioned as occurring occasionally on the sandy plateau bordering the sea beach.[3]

At about the level of Wade's Shore the open woodland begins to be succeeded by dune marshes. Here the black soil retains the rain-water, which stands at a level of 6-12 inches, and which is brown in color like the "Juniper water" of the Dismal Swamp. These marshes are not of great extent and lie on the seaward side, near the wall of advancing sand.

From this point to Cape Lookout both forest and swamp have disappeared completely save for one or two small groves of live oak, which

[1]Fig. 4.
[2]Fig. 5.
[3]Fig. 7.

A. Open woodland, the sand drifting in to the right. *Quercus virginiana* and *Juniperus virginiana*



B. Salt marshes *(Spartina* and *Salicornia)* near the Fisheries Laboratory (Photo by R. E. Coker)

have been able to resist the advancing sand. Elsewhere this portion of the island is a sandy waste, with little or no vegetation, except that in the lower places may be seen evidences of the swamps that existed here before the advancing sand covered the island from the sea to the sound. In such low flat areas *Scirpus americanus* and *Fimbristylis castanea*, most tolerant of sand and drought of all the marsh species, continue to exist side by side with *Croton punctatus*, *Salsola Kali*, and *Cenchrus tribuloides*, plants at home on the sand strand. *Paspalum distichum* often covers the ground with a weak but uniform turf in such spots, and *Spartina patens* is usually present.

The sand strand also does not extend east of Wade's Shore, but gives way to the flat salt marshes, which border the sound.

Not far from Cape Lookout, about 400 yards from the sea, are dunes some 40 feet high. In the lee of these are fresh pools, fed by seepage from the dunes. *Acorus Calamus* and *Salix sp.* are here present, while around the pools are the shrubs of the thicket formation occurring toward the western end of the island.

THE VEGETATION OF BOGUE BANK

On this bank, which extends west from Beaufort Inlet, physiographic conditions have produced a much more stable configuration than on Shackleford. A line of dunes about 20 feet high, formed and covered by sea-oats (*Uniola*) extends along the bank, and protects the vegetation in its lee from the encroachments of drifting sand. Back of the dunes on the eastern end of the bank for a distance of about five miles the ground is covered by thickets somewhat like those described for Shackleford, though the woody plants are here smaller and more shrubby. *Ilex vomitoria* is the dominant shrub, while *Zanthoxylum Clava-Herculis* and *Juniperus virginiana* are common. In the more open places are the herbs and shrubs characteristic of similar localities on Shackleford.

From about five miles west of the Inlet, the Hoop Pole woods cover the bank, the beach being here quite narrow. The woods are protected by a barrier dune, or sand wall, held in place by *Uniola* and various sand-binding herbs and shrubs, among which a low form of *Ilex vomitoria* is abundant. The Hoop Pole woods themselves are composed mostly of hardwood trees of considerable size, with an admixture of pines and cypresses. The forest here is quite similar to that of the adjacent mainland, and here flourish many plants which cannot endure the severer conditions on Shackleford. Botanically, Bogue Bank from Bogue Inlet to the eastern end of the Hoop Pole woods (about 20 miles) is a continuation of the mainland.

CONSERVATION OF THE VEGETATION

The vegetation of Shackleford Bank is described at some length because of the rapid changes in the physiography of the region now taking place. In the memory of living inhabitants, the Bank was well wooded over its entire extent, the strand separating the forest from the ocean beach being so narrow that it was "possible to sit in a tree and cast a fishing line into the water." Before the Civil War, however, cutting of timber, coupled with forest fires, the grazing of cattle and sheep, and the inroads of gales, had broken the protecting wall of vegetation and allowed the sand from the beach to blow in on the trees. Slowly at first, and then more and more rapidly, the sand was blown in on the vegetation, killing or covering the existing plants. At the present time the forest east of Wade's Shore (see map) has been destroyed, and this portion of the Bank is a sandy waste, with here and there a wind-blown dune sheltering a remnant of the former vegetation. In the western and wider portion of the Bank the progress of the sand has been slower, and perhaps half of the original plant covering remains. Here the work of destruction is going on at a rapid rate. The dry sand, blowing over the wide beach, is carried to the edge of the forest and there falls over a slope of an angle of about 30°. This sloping sand-wall is advancing on the forest at a rate of 4 to 12 feet a year and killing all vegetation in its path. As the beach broadens, the sand will drift in with increasing rapidity, until within a comparatively few years the forest-covering will be obliterated.

The results of this will be twofold. It will probably lead to the abandonment of Shackleford Bank as a permanent place of residence, because without the protection afforded by the vegetation, the winter storms will sweep over the land with such force as to make residence unsafe. In the second place, the sand will continue to drift north with increasing rapidity, and this will have a tendency to fill in the rather narrow sound lying between the bank and the mainland. The hindrance thus caused will be slight, because few boats now pass this way, the channel being tortuous and in places quite shallow. Of more importance will be the effect of the closing of the channel on the fisheries of the region. The enormous number of mullet and other fish now coming through Core Sound to Beaufort Inlet would pretty certainly be diverted to some other inlet farther northeast. Whether this would result in a diminution of the total catch of Pamlico and Core sounds, or whether the loss at one point would be compensated for by a gain at another, cannot be stated. At any rate there would be a serious disturbance to the conditions which now make fishing profitable in this region.

A. Creek marsh and thicket woodland

B. Creek marsh and thicket woodland

For these two practical reasons, then, it seems desirable to protect the existing vegetation of Shackleford from further destruction by drifting sand. A third reason is not less important. From Cape Henry southward along our entire Atlantic Coast similar conditions are met with. What are now forest lands, some quite valuable, are being converted into sandy wastes. The methods which have proved successful in other parts of the world[1] in controlling shifting sands and converting them into forest lands have never been tried in this section to any extent, and it would be of practical and scientific value to conduct experiments along this line on Shackleford Bank. The area to be protected is rather small, so the cost of the experiments would not be very great.

The first step in such reclamation and conservation work would be the production of a barrier dune running along the sea beach similar to that employed on the Kurische Nehrung in Germany and on the southwestern coast of France. The first step in the formation of such a dune would be to form a long ridge of sand, 10-12 feet high, by means of a brush fence. This should consist of two rows of rough stakes or untrimmed branches, driven firmly into the sand and projecting two or more feet above the surface. Such a fence should be set 100 feet from the sea. It would cause the drifting sand to accumulate in a long ridge. When the ridge becomes 10 or 12 feet high, sea oats (*Uniola paniculata*) should be set out after the manner used in other countries in transplanting the sea marram (*Ammophila arenaria*). With some attention a barrier dune would be thus formed similar to that now protecting the Hoop Pole woods on the neighboring Bogue Bank.

After the barrier dune is formed, the region back of it, now a sandy plateau, should be planted in loblolly pine (*Pinus taeda*). The work of reclamation would then be complete, and occasional attention to the barrier dune, with the purpose of repairing accidental breaks due to storms, and preventing blow-outs, would make it permanent.

If the barrier dune is once formed, the work of reclaiming the sandy plateau would be greatly aided by various native plants. Of these the most important are *Spartina juncea, Fimbristylis castanea, Physalis viscosa,* and *Paspalum distichum. Ilex vomitoria,* which seeds very freely, would aid materially in providing a windbreak for the young pines. All the plants mentioned are valuable sand binders, since they have long branching roots or rhizomes which tend to hold the sand. Occasional clumps of *Salsola Kali, Cenchrus tribuloides, Oenothera humifusa, Euphorbia polygonifolia,* and *Solidago sempervirens* would also occur on such a formation, but would be of less importance because their roots strike vertically, rather than horizontally, into the sand.

[1]Hitchcock, A. S., Methods used for controlling and reclaiming sand dunes: Bull. 57, Bureau of Plant Industry.

The entire strip involved in such an experiment as that suggested is about three miles long. The cost of building the brush fence cannot be stated with certainty, but would be in the neighborhood of $500, while planting the sea oats would cost perhaps $200 more.[1] The ultimate success of the operations would depend very largely on having a competent man to inspect the barrier dune occasionally, say once a month, and repair breaks by means of sand fences.

The prohibitive cost of the reclamation operations suggested by Bond[2] is estimated from his study of the conditions obtaining at Hatteras. The actual cost of reclamation work on Shackleford would be less than estimated by Bond, for the following reasons: (1) The fence need not be of board, since experience in other localities proves that sand is held sufficiently well by a rough fence or hedge built of untrimmed branches driven into the sand. (2) The sand ridge need not be built up to the height of 30 feet, as recommended by Bond. After the ridge has been raised 6 feet or so from the level of the beach, sea oats should be planted. This species, by its natural growth, would build up the ridge to the desired height.

These two matters are mentioned to show that the estimates of Bond were made without sufficient regard to the local conditions. His recommendations are taken from Hitchcock's paper (l. c.) on Controlling and Reclaiming Sand Dunes, which is based on a study of the methods used in the "Netherlands, Denmark, Germany, and France" (p. 5). These methods, to be successful on our coasts, must be adapted to local conditions, and a study of these conditions must precede successful reclamation work. The results of such a study I have endeavored to include in the present account.

SAND AND SOIL BINDING PLANTS AND THEIR ACTIONS

The character of the soil around Beaufort is such that physiographic agencies act rapidly. The sandy shoals in the sound, and therefore the channels, are constantly being shifted by tidal currents. The sands of the "banks" are extremely unstable, and are continually being moved about by the wind. There are certain natural agencies, however, which tend to check this extensive movement of the soil, and which must be the basis of any permanent fixation of the land. These are the work of sand and soil binding plants, somewhat similar to but not identical with the plants of the same function in other parts of the world.[3]

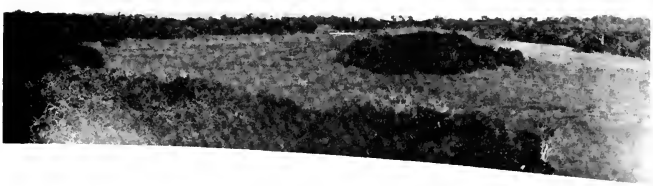
A brief account of these plants and their action will be given here.

[1] These estimates were made in 1909, and must be modified on account of the great increase in the cost of labor.

[2] Biennial Report of the State Geologist, N. C. Geological and Economic Survey, pp. 42-48, Raleigh, 1908.

[3] See Hitchcock, l. c.

A. Dune marsh and thicket woodland; on the right the advancing sand wall



B. View from the sand wall across the island to the sound

SOIL-BUILDING PLANTS

The most important are *Spartina glabra*, *Salicornia ambigua*, and *Borrichia frutescens*. These are plants of the salt-marsh, and live only in situations where the soil is flooded at high tide, and where the water is comparatively quiet. They are an important factor in the formation of the numerous flat, marshy islands lying in Bogue Sound and around the mouth of Newport River. At first, sandy flats, quite bare of vegetation, are formed by the currents due to wind and tide. *Spartina* may gain a precarious foothold on the loose sand. It then sends its strong, thick rhizomes here and there, binding the sand on which it grows, adding humus, collecting and holding silt brought down by the rivers. In such situations the grass is stunted and sparse, but by thrusting a spade into the sand one sees that the substratum is closely occupied by the long heavy branching rhizomes long before the conditions are sufficiently favorable for the aerial part of the plant to send up its flowering stalks or even to produce very vigorous foliage. At this stage *Salicornia ambigua* may also gain a foothold and aid in reclaiming the sandy wastes. The building up is accomplished partly by the plants catching and holding the sand and silt brought to them by the currents and partly by the actual addition of dead and rotted plant substance. After these forces have been at work for some time the land may be raised nearly or quite out of reach of high tides, and invaders begin to appear in the highest ground and help build it up further. The common invaders in such situations are *Borrichia frutescens*, *Limonium carolinianum*, *Solidago sempervirens*, *Strophostyles umbellata*, *Ira oraria*, and *Spartina patens*.

All stages of this island-formation can be observed near the Fisheries Laboratory. On Shark Shoal[1] south of the Laboratory, the *Spartina* has just been established. To the north are broad flats of marsh with *Spartina*, *Salicornia*, and *Borrichia*. Where the currents of the water have aided in building up the land the other species mentioned above are to be seen. The town marsh is in a still later stage of development; woody species such as *Myrica cerifera*, and various grasses and herbs, have appeared.

Changes in the small islands of the sound are not all progressive. When the direction of the tidal currents is changed for any reason, the result may be the denudation of land already built up. Such denudation has occurred in a striking way on Bird Shoal, just south of the town of Beaufort. This island was, twenty years or so ago, of an elevation of 15 or 20 feet, and covered with a vigorous growth of plants,

[1] *Spartina* has also been planted on Shark Shoal.

including sea oats (*Uniola*), *Myrica cerifera,* and many other species both shrubby and herbaceous. The action of storms, however, combined with changes in the direction of the tidal currents, has resulted in leveling this land until it is now completely covered at mean high tide. The only vegetation now occurring here is a sparse growth of *Spartina glabra.*

Another method of island-formation in neighboring waters has been described by Grave.[1]

SAND-BINDING PLANTS

Methods for controlling and reclaiming shifting sands have been well worked out in other regions, and it is known with tolerable certainty just what may be expected of any species of sand-binding plants under given conditions. These conditions are the same the world over. High winds playing over dry sand furnish conditions for plant life that call for specially modified species to withstand them.

In controlling shifting sand, the first step is usually the formation of a barrier dune which will catch and break the full force of the wind; second, the sand back of the dune must be held in place until it can be forested; third, the forest must become established in the lee of the barrier dune.

For forming the barrier dune, beach grass (*Ammophila arenaria*) has been almost universally used. This species is not available at Beaufort. Its place is well supplied, however, by the sea oats (*Uniola paniculata*), which possesses all the features that make beach grass valuable in other localities. Its leaves are sufficiently tough to resist the action of blasts of dry sand driven at high speed. They are too flexible to be broken by direct action of the wind. The root-stocks are strong, heavy, and branching, and strike both vertically and obliquely into the sand, so that the plant is securely anchored, and the sand firmly held. Lastly, the constant movement of the sand is rather beneficial than injurious to *Uniola.*

That this species may be successfully used in forming a barrier dune is evidenced by Bogue Bank in the neighborhood of the Hoop Pole wood. Here the dune is stable, and furnishes complete protection to the forest.

The sea oats will prove most valuable in controlling shifting sand. It is not available, however, for reclaiming sandy wastes, for the reason that it flourishes only where the sand is constantly moving. Where the sand, sheltered by a barrier dune, is comparatively stable, other species

[1]Grave, C., Investigations for the Promotion of the Oyster Industry in North Carolina; U. S. Fish Commission Report, pp. 260-264. 1903.

A. Sand wall advancing on woodland

B. "Graveyard" of forest, some of the dead trees covered with lianas

are required to hold it in place and, by the addition of humus, to furnish the conditions necessary for a permanent plant covering. Of these species, by far the most valuable in this locality are *Spartina patens* (*S. juncea*) and *Physalis viscosa*. The latter possesses the toughness of leaf necessary to resist the driving particles of sand, and has, in addition, very long, slender, tough, branching root-stocks, which are admirably adapted to hold in place the sand throughout a considerable area around each individual plant. In one plant one of the root-stocks, not including the branches, was found to be upwards of 45 feet in length. Furthermore, *Physalis* is a perennial plant which sets seed freely. *Spartina patens* possesses the same advantages, although the root-stocks are not so long, and is, in addition, more able to resist adverse conditions. The other species which flourish on more or less unstable sand, such as *Euphorbia polygonifolia, Croton punctatus, Cenchrus tribuloides,* and others, are not so valuable as sand binders, because they lack the extensive branching root-stocks of the two species mentioned first, and because the majority (*Croton punctatus* is an exception to this rule) are annual plants, which are useful only in the summer. One shrubby plant, *Iva oraria,* would prove valuable if it could endure the severe conditions obtaining on sandy areas exposed to the full sweep of the wind; this has not yet been demonstrated. Figure X, *B*, shows this species forming a stable dune where it is somewhat protected from the wind. Another, *Ilex vomitoria,* is an efficient sand binder and an excellent windbreak when it once gets a foothold. It is difficult to transplant, however, and it is somewhat doubtful whether it would grow from seed in exposed sandy localities. If any reclamation operations are undertaken, efforts should be made to establish it on the exposed sand.

GEOGRAPHICAL DISTRIBUTION OF SHACKLEFORD PLANTS

The entire chain of sandbanks along the North Carolina coast lies in the Austro-riparian area of the Lower Austral Zone.[1] This area includes the coast region beginning from the mouth of the Chesapeake Bay and the coastal plain region of the South Atlantic and Gulf States from North Carolina to Texas, with the exception of the southern extremity of Florida. An analysis of the flora of Shackleford shows the Austro-riparian element to be dominant at this place. Over 24 per cent of the total number of plants listed are characteristic of the flora of this area. These are as follows:

[1]See Merriam, The Geographical Distribution of Animals and Plants in North America: Year Book, U. S. Department of Agriculture, 1894, pp. 203-214. Also, Life Zones and Crop Zones of the United States, Bull. 10, Biol. Survey, 1898.

1. Maritime species:

Borrichia frutescens ‡ *	Seutera (Vincetoxicum) palustris † *
Croton punctatus † *	Suaeda (Dondia) linearis † *
Cyperus tetragonus †	Uniola paniculata ‡ *
Eustachys petraea † *	Yucca aloifolia † *
Heliotropium curassivicum ‡ *	—
Physalis viscosa ‡ *	10

2. Species normally occurring near the coast:

Berchemia scandens ‡	Laurocerasus caroliniana †
Callicarpa americana ‡	Lyonia (Pieris) nitida ‡ *
Cicuta curtissii ‡	Osmanthus americanus †
Cissus (Ampelopsis) arborea ‡ *	Panicum lancearium ‡
Cyperus haspan ‡ *	Paspalum distichum ‡ *
Cyperus microdontus ‡ *	Persea borbonia ‡
Fimbristylis spadicea ‡ *	Persea pubescens †
Gaura augustifolia †	Quercus virginiana ‡ *
Gelsemium sempervirens ‡	Rubus trivialis ‡
Ilex vomitoria ‡	Sacciolepis striata ‡ *
Ipomoea sagittata † *	Solanum gracile † *
Iva imbricata ‡ *	Vincetoxicum suberosum ‡
Jatropha stimulosa ‡	Zanthoxylum Clava-Herculis ‡ *
Kneiffia arenicola †	—
Ludvigia alata †	29
Ludvigia microcarpa †	

3. Species occurring normally on the costal plain:

Arenaria lanuginosa † *	Ludvigia virgata †
Cladium jamaicense ‡ *	Paspalum laeve australe ‡
Commelina angustifolia †	Passiflora incarnata ‡ *
Croton glandulosus ‡ *	Polygonum setaceum †
Cynoctonum mitreola ‡ *	Sporobolus indicus ‡ *
Dichromena latifolia ‡	Stenophyllus stenophyllus †
Eleocharis ochreata ‡ *	Vaccinium arboreum †
Eupatorium capillifolium ‡ *	—
Juncus megacephalus †	16

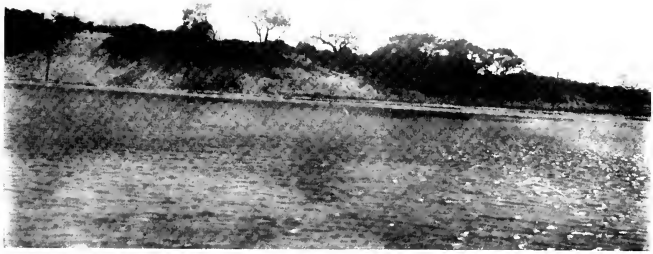
Total number of strictly Austro-riparian species occurring on Shackleford, 55.

To this list may be added ten species which are stated by Small not to occur north of South Carolina. The ranges quoted are taken from Small's Southern Flora. These species are:

Andropogon tetrastachyus ("South Carolina to Florida and California").
Anychiastrum Baldwinii ("Georgia to Louisiana and Florida").
*Eleocharis microcarpa ("Florida to Louisiana. Also in Cuba").
*Lagenaria vulgaris ("Gulf States and throughout the Tropics").

*Also in tropics.
†Northern limit North Carolina.
‡Northern limit Virginia.

A. Dead *Juniperus* covered with lianas



B. View of High Hill from the sound, showing the rise of the land at this point

Lippia nodiflora ("Georgia to Florida").
Paspalum floridanum ("South Carolina to Florida, west to Texas").
Rubus persistens ("South Carolina to Florida and Mississippi").
Rynchospora stipitata ("In river swamps, Florida").
Sabal glabra ("South Carolina to Florida and Louisiana").
*Verbena polystachya ("Florida, through the Gulf States to California").

Spiranthes ovalis has also not been reported from this State. *Festuca rubra* ranges from Labrador to Virginia, mostly near the coast.

Of the species listed which are not confined to the Austro-riparian area, 27 are maritime and 28 usually occur along the coast. The northern limits of these species are from Nova Scotia to Maryland. With few exceptions they range all along the shores of the South Atlantic and Gulf States.

Of the remaining species, the great majority are weeds of wide distribution, and not confined to or characteristic of any one phytogeographical area. Of these, 137 range practically throughout the United States except on the Pacific slope, while 21 occur throughout the Carolinian and Austro-riparian areas. Leaving out of consideration these species and the wide-ranging strand-forms, it is seen that the flora of Shackleford is almost typically Austro-riparian in its character. The absence of many forms usually occurring in this area[1] is to be attributed, no doubt, to the severe conditions for plant life on the sand banks, since these species are abundant on the mainland, only one to two miles away.

It is worthy of note that the species found also in more northern areas which extend as far south as Beaufort, usually extend also throughout the Austro-riparian area to Florida and the Gulf States. There are only ten exceptions to this rule, or 3 per cent of the whole. In the list the northern and southern limits are indicated in parentheses.

Allium vineale (Connecticut to Georgia).
Amaranthus pumilus (Rhode Island to South Carolina).
Celtis occidentalis (Quebec to North Carolina).
Chenopodium Botrys (Nova Scotia to Georgia).
Digitaria filiformis (Massachusetts to North Carolina).
Festuca rubra (Labrador to Virginia).
Panicum dichotomum (Connecticut to Georgia).
Panicum spretum (New York to Georgia).
Polypogon monspeliensis (New Hampshire to South Carolina).
Vitis labrusca (New England to Georgia).

[1]See Kearney, l. c., p. 314.

COMPARISON OF BEAUFORT FLORA WITH THAT OF OTHER LITTORAL REGIONS

	Species	Genera
I. *Ocracoke Island* (Kearney, l. c.)—		
Total number	135	111
Also found at Beaufort	107	99
Per cent common to both localities	79.2	89.2
II. *Isle of Palms, S. C.*[1]		
Total number	115	96
Also found at Beaufort	81	88
Per cent common to both localities	70.4	91.6
Per cent common to Ocracoke and Isle of Palms	40.8	
III. *Alabama*[2]—		
Total number	107	83
Also found at Beaufort	41	56
Per cent common to both localities	38.3	67.4
IV. *Florida Keys*[3]—		
Total number	84[4]	76
Also found at Beaufort	9	25
Per cent common to both localities	10.7	32.9

Of the species listed by Mohr for Alabama, only those are counted here which are stated to occur in the littoral belt. The great majority of Beaufort species occur in the coastal plain region of Alabama, while only 41 per cent are characteristic of the littoral belt. The table serves to show how closely the floras of littoral North and South Carolina approximate, and also how much more nearly similar the floras of Alabama and Beaufort are than those of the Florida Keys and Beaufort. Of the regions compared, the Florida Keys are alone outside the Austro-riparian area.

[1]Coker, W. C., Observations on the Flora of the Isle of Palms, Charleston, S. C.; Torreya, V, 135-145, 1905.

[2]Mohr, C., Plant Life of Alabama; Contributions from the U. S. National Herbarium, VI, 921, pp., 1901.

[3]Millspaugh, C. F., Flora of the Sand Keys of Florida; Publications of the Field Columbian Museum, II, 191-245, 1907.

[4]Of these, 62 are confined to Florida and the tropics.

A. Isolated grove of live-oak *(Quercus virginiana)* on mainland; similar to those on Shackleford. (Photo by W. D. Hoyt)

B. Small dune formed by *Iva oraria*; in the foreground is *Spartina patens*

LIST OF SPECIES[1]

POLYPODIACEÆ

i Aspidium Thelypteris (L.) Sw.; Dryopteris Thelypteris (L.) A. Gray.
e Asplenium platyneuron (L.) Oakes.
f‡ Onoclea sensibilis L.
f Polypodium polypodioides (L.) Hitch.
f Pteris aquilina L.

OSMUNDACEÆ

f Osmunda regalis L.

PINACEÆ

e Juniperus virginiana L.
f Pinus taeda L.

TYPHACEÆ

h Typha augustifolia L.

SPARGANIACEÆ

*i** Sparganium americanum Nutt. var. androcladum (Engelm.) Fern. & Eames.; (S. androcladum (Eng.) Morong).

NAJADACEÆ

Zostera marina L.

JUNCAGINACEÆ

h Triglochin striata R. & P.

ALISMACEÆ

* Saggittaria lancifolia L.
i Saggittaria latifolia Willd.

GRAMINEÆ

i† Andropogon tetrastachyus Ell.
a.b Cenchrus tribuloides L.
Cynodon Dactylon (L.) pers.; (Capriola Dactylon (L.) Ktze).
Digitaria filiformis (L.) Koeler; (Syntherisma filiformis (L.) Nash).
Digitaria sanguinalis (L.) Scop.; (Syntherisma filiformis (L.) Nash).
h Distichlis spicata (L.) Greene.
i Echinochloa Walteri (Pursh.) Nash; (Panicum Walteri Pursh).
Eleusine indica (L.) Gaert.
Elymus virginicus L.
Eragrostis pectinacea (Michx.) Steud.
a Eustachys petraea (Sw.) Desv.; (Chloris petraea Sw.).
†* Festuca rubra L.
Panicum Sp.
i Panicum amarum Ell.
Panicum anceps Michx.
c Panicum commutatum Schultes.
c Panicum dichotomum L. (?)
Panicum lanceraerium Trin. (?); (P. Nashianum Scribn.(?)).
c Panicum lanuginosum Ell.; (P. pubescens Lam.).
c Panicum sphaerocarpon Ell.
e Panicum spretum Schultes(?); (P. nitidum Lam.(?)).
i Panicum virgatum L.
Paspalum ciliatifolium Michx.
j Paspalum distichum L.
† Paspalum floridanum Michx.
Paspalum laeve Michx. var. australe Nash.
Phleum pratense L.
Polypogon monspeliensis (L.) Desf.
i Sacciolepis striata (L.) Nash; (Panicum gibbum Ell.).
h Setaria imberbis R. & S. var. perennis (Hall) Hitch.; (Chaetochloa versicolor Bickn.).
g Spartina glabra Muhl.; (S. stricta (Ait.) Roth.).
a.b Spartina patens (Ait.) Muhl. var juncea (Michx.) Hitch.

[1]No collections were made later than August, and it is therefore probable that some of the late-blooming species are not included. This applies especially to the Compositæ.

Sporobolus indicus (L.) R. Br.
c Stipa avenacea L.
e Triplasis purpurea (Walt.) Chapm.; (Sieglingia purpurea (Walt.) Ktze.).
e Uniola laxa (L.) B. S. P.
b Uniola paniculata L.
Muhlenbergia capillaris Curtis.

CYPERACEÆ

i Cladium jamaicense Crantz; (C. effusum (Sw.) Torr.).
i Cyperus cylindricus (Ell.) Britton.
i Cyperus ferax Rich.; (C. speciosus Vohl.).
i Cyperus flavescens L.
i Cyperus haspan L.
i Cyperus microdontus Torr.
h Cyperus Nuttallii Eddy.
*i** Cyperus retrofractus (L.) Torr.
i Cyperus strigosus L.
i Dichromena colorata (L.) Hitch.
*i** Dichromena latifolia Baldw.
i Dulichium arundinaceum (L.) Brittton.
h Eleocharis albida Torr.
i Eleocharis microcarpa Torr.
h Eleocharis ochreata (Nees) Steud.
h Eleocharis Robinsii Oakes. (?)
Fimbristylis autumnalis (L.) R. & S.
h Fimbristylis castanea (Michx.) Vahl.
h Fimbristylis spadicea (L.) Vahl.
i Fuirena hispida Ell.
i Rynchospora glomerata (L.) Vahl.
i† Rynchospora stipitata Chapm.
h Scirpus americanus Pers.
h Scirpus validus Vahl.; (S. lacustris Am. auth.).
f Scleria triglomerata Michx.
f Stenophyllus stenophyllus (Ell.) Britton.

PALMÆ

f† Sabal glabra Mill.) Sarg.; (S. Adansonii Guerns.).

ARACEÆ

i Acorus Calamus L.

XYRIDACEÆ

*d** Xyris arenicola Small; (X. torta J. E. Smith).

COMMELINACEÆ

Commelina sp.
d Commelina angustifolia Michx.

JUNCACEÆ

Juncus marginatus Rostk.
h Juncus megacephalus Curtis.
h Juncus Roëmerianus Scheele.
f Juncus setaceus Rostk.
f Juncus tenuis Willd.

LILLIACEÆ

* Allium vineale L.
e Smilax Bona-nox L.
e Smilax glauca Walt.
e Smilax laurifolia L.
d Yucca aloifolia L.

ORCHIDACEÆ

Spiranthes ovalis Lindl.(?); (Gyrostachys parviflora (Chapm.) Small(?)).

PIPERACEÆ

i‡* Saururus cernuus L.

SALICACEÆ

i Salix sp.

MYRICACEÆ

d Myrica carolinensis Mill.
e Myrica cerifera L.

JUGLANDACEÆ

*f** Carya glabra (Mill.) Spach.; (Hicoria glabra (Mill.) Britton).

BETULACEÆ

f Carpinus caroliniana Walt.

Ilex vomitoria as a wind-break in exposed localities

FAGACEÆ

*f** Quercus falcata Michx.; (Q. digitata Sudw.).
f Quercus nigra L.; (Q. aquatica Walt.).
f Quercus phellos L. var. laurifolia (Michx.) Chapm.
*f** Quercus stellata Wang.; (Q. minor (Marsh) Sarg.).
e,f Quercus virginiana Mill.

URTICACEÆ

i Boehmeria cylindrica (L.) Sw.
Celtis occidentalis L.
f Morus rubra L.
i Parietaria floridana Nutt.
i Pilea pumila (L.) Gray; (Adicea pumila (L.) Raf.).

LORANTHACEÆ

f Phoradendron flavescens (Pursh.) Nutt.

POLYGONACEÆ

i Polygonum acre H. B. K. var. leptostachyum Meisn.; (P. punctatum Ell. var. leptostachyum (Meisn.) Small).
Polygonum lapathifolium L.
a Polygonum maritimum L.
i Polygonum setaceum Baldw.
* Rumex hastatulus

CHENOPODIACEÆ

a Atriplex arenaria Nutt.
Atriplex patula L. (?)
a Chenopodium anthelminticum L.
a Chenopodium Botrys L.
a Chenopodium glaucum L.
a Chenopodium viride L.
g Salicornia ambigua Michx.
g Salicornia mucronata Bigel.; (S. Bigelowii Torr.).
a,b Salsola Kali L.
h Suaeda linearis (Ell.) Moq.; (Dondia linearis (Ell.) Millsp.).

AMARANTHACEÆ

c Acnida cannabina L.
b Amaranthus pumilus Raf.

PHYTOLACCACEÆ

Phytolacca decandra L.

AIZOACEÆ

a Sesuvium maritimum (Walt.) B. S. P.

CARYOPHYLLACEÆ

f Arenaria lanuginosa (Michx.) Rohrb.
c† Anychiastrum Baldwinii (T. & G.) Small.

PORTULACCACEÆ

a Portulaca oleracea L.

MAGNOLIACEÆ

f Magnolia virginiana L.

LAURACEÆ

e,f Persea borbonia (L.) Spreng.
e,f Persea pubescens (Pursh) Sarg.
f Sassafras variifolium (Salisb.) Ktze.; (S. officinale Nees. and Eberm.).

CRUCIFERÆ

f Lepidium virginicum L.

ROSACEÆ

Laurocerasus caroliniana (Mill.) Roem.
Rosa carolina L.
d Rubus trivialis Michx.
† Rubus persistens Rydb. (?)

LEGUMINOSÆ

f Apios tuberosa Moench.
d Cassia chamaecrista L.
e Desmodium paniculatum (L.) DC.; (Meibomia paniculata (L.) Ktze.).

e Galactia volubilis (L.) Britton.
e Strophostyles umbellata (Muhl.) Britton.
Trifolium repens L.

LINACEÆ

f Linum medium (Planch.) Britton.

RUTACEÆ

e Zanthoxylum Clava-Herculis L.

SIMARUBACEÆ

f Ailanthus glandulosa Desf.

MELIACEÆ

Melia Azedarach L.

POLYGALACEÆ

i Polygala verticillata L.

EUPHORBIACEÆ

e Acalypha gracilens Gray.
d Croton glandulosus L. var. septentrionalis Muell. Arg.
a,b Croton punctatus Jacq.
f Euphorbia sp.
a Euphorbia maculata L.
b Euphorbia polygonifolia L.
f Jatropha stimulosa Michx.
Ricinus communis L.

ANACARDIACEÆ

Rhus copallina L.
c,f Rhus toxicodendron L. var. radicans Torr.

AQUIFOLIACEÆ

e Ilex glabra (L.) Gray.
f Ilex opaca Ait.
d,e,f Ilex vomitoria Ait.

RHAMNACEÆ

e,f Berchemia scandens (Hill) Trel.

VITACEÆ

e Cissus arborea (L.) Des. Moul.; (Ampelopsis arborea (L.) Rusby).
e Psedera quinquefolia (L.) Greene; (Parthenocissus quinquefolia (L.) Planch.).
e Vitis aestivalis Michx.
e Vitis labrusca L.
e Vitis rotundifolia Michx.

TILIACEÆ

f Tilia Michauxii Nutt.; Tilia pubescens Ait.).

MALVACEÆ

i Kosteletzkya virginica (L.) Presl.

TAMARICACEÆ

Tamarix gallica L.

HYPERICACEÆ

e Ascyrum hypericoides L.
e Hypericum mutilum L.
i Hypericum virginicum L.; (Triadenum virginicum (L.) Raf.).

CISTACEÆ

e,f Lechea villosa Ell.

PASSIFLORACEÆ

e Passiflora incarnata L.
e Passiflora lutea L.

CACTACEÆ

d Opuntia vulgaris Mill.; (Opuntia opuntia (L.) Coult.).

LYTHRACEÆ

i Amannia Koehnei Britton.
*i** Decodon verticillatus (L.) Ell.
i Lythrum lineare L.

ONAGRACEÆ

d Gaura angustifolia Michx.
d Kneiffia arenicola Small.
i Ludvigia alata Ell.
i Ludvigia microcarpa Michx.
i Ludivigia palustris (L.) Ell.; (Isnardia palustris L.).

i Ludvigia virgata Michx.
e Oenothera humifusa Nutt.

HALORAGIDACEÆ

*i** Myriophyllum verticillatum L.
i Proserpinaca pectinata Lam.

ARALIACEÆ

f Aralia spinosa L.

UMBELLIFERÆ

h Centella asiatica (L.) Urban.; (C. repanda (Pers.) Small).
f Cicuta Curtissii Coult. & Rose.
h Hydrocotyle umbellata L.
i Hydrocotyle verticillata Thunb.
h Lilaeopsis lineata (Michx.) Greene.
h Ptilimnium capillaceum (Michx.) Raf.
e Sanicula canadensis L.

CORNACEÆ

f Cornus florida L.

ERICACEÆ

*f** Lyonia nitida (Bartr.) Fernald; (Pieris nitida (Bartr.) B. & H.).
*f** Vaccinium arboreum Marsh.

PLUMBAGINACEÆ

h Limonium carolinianum (Walt.) Britton.

PRIMULACEÆ

h Samolus floribundus HBK.

EBENACEÆ

f Diospyros virginiana L.

OLEACEÆ

f Osmanthus americana (L.) B. & H.

LOGANIACEÆ

i Cynoctonum mitreola (L.) Britton.
e Gelsemium sempervirens (L.) Ait. f.

GENTIANACEÆ

h Sabatia stellaris Pursh.

APOCYNACEÆ

e Apocynum cannabinum L.

ASCLEPIADACEÆ

i Asclepias lanceolata Walt.
h Seutera palustris (Pursh.) Vail.; (Vincetoxicum palustre (Pursh.) Gray).
e Vincetoxicum suberosum (L.) Britton.

CONVOLVULACEÆ

i Cuscuta arvensis Beyrich.
i Ipomoea sagittata Cav.

BORAGINACEÆ

a Heliotropium curassavicum Cav.

VERBENACEÆ

e Callicarpa americana L.
i Lippia nodiflora (L.) Michx.
i† Verbena polystachya HBK.

LABIATÆ

Marrubium vulgare L.
e,f Monarda punctata L.
* Teucrium canadense L. var. littorale (Bicknell) Fernald.
i Trichostema dichotomum L.

SOLLANACEÆ

Datura Stramonium L.
a Physalis pubescens L.
a Physalis viscosa L.
a Solanum carolinense L.
a Solanum gracile Link.

SCROPHULARIACEÆ

h Bacopa Monniera (L.) Wettst.; (Monniera Monniera (L.) Britton).
h Gerardia maritima Raf.
Verbascum Thapsus L.

LENTIBULARIACEÆ

*i** Utricularia purpurea Walt.

PLANTAGINACEÆ

* Plantago lanceolata L.

RUBIACEÆ

i Diodia virginiana L.
i Diodia teres Walt.
e Galium hispidulum Michx.
e Galium pilosum Ait. var. puncticulosum (Michx.) (T. & G.).
e Mitchella repens L.

CAPRIFOLIACEÆ

e Lonicera sempervirens L.

CUCURBITACEÆ

a Lagenaria vulgaris Ser.; (Lagenaria Lagenaria (L.) Cock.).
d,e Melothria pendula L.

AMBROSIACEÆ

f Ambrosia artemisaefolia L.
a Iva oraria Bartl.; (I. frutescens L.).
a Iva imbricata Walt.
a Xanthium sp.

CICHORIACEÆ

e Hieracium Gronovii L.
f Lactuca canadensis L.
* Sonchus asper (L.) Hill.

CARDUACEÆ

a Baccharis halimifolia L.
Bidens bipinnata L.
g Borrichia frutescens (L.) DC.
* Carduus sp.
e Cirsium spinosissimum (Walt.) Scop.; (Carduus spinosissimus Walt.).
i Eclipta alba (L.) Hassk.
e,f Elephantopus nudatus Gray.
e Erechthites hieracifolia (L.) Raf.
e Erigeron canadensis L.; (Leptilon canadensis (L.) Britton).
Eupatorium capillifolium (Lam.) Small.
Heterotheca subaxillaris (Lam.) Britton and Rusby.
e,i Mikania scandens (L.) Willd.; (Willughbaea scandens (L.) Ktze.).
i Pluchea camphorata (L.) DC.
i Pluchea foetida (L.) B. S. P.
Senecio vulgaris L.
f Solidago odora Ait.
e Solidago sempervirens L.

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*Not collected on Shackleford, but on some of the neighboring islands.
†Range here extended.
‡Listed by Johnson [2], not observed by the writer.
a Characteristic of the inner beach formation.
b Outer beach formation.
c Dune formation.
d Thicket formation.
e Thicket woodland formation.
f Woodland formation.
g Salt marsh formation.
h Creek Marsh formation.
i Dune marsh formation.
j Tidal flat formation.

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[2] Johnson, D. S., Notes on the Flora of the Banks and Sounds at Beaufort, N. C.: Bot. Gazette, 30, 405-409, 1900.

PUBLICATIONS

OF THE

NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY

BULLETINS

1. Iron Ores of North Carolina, by Henry B. C. Nitze, 1893. 8°, 239 pp., 20 pl., and map. *Out of print.*

2. Building and Ornamental Stones in North Carolina, by T. L. Watson and F. B. Laney in collaboration with George P. Merrill, 1906. 8°, 283 pp., 32 pl., 2 figs. *Postage 25 cents. Cloth-bound copy 50 cents extra.*

3. Gold Deposits in North Carolina, by Henry B. C. Nitze and George B. Hanna, 1896. 8°, 196 pp., 14 pl., and map. *Out of print.*

4. Road Material and Road Construction in North Carolina, by J. A. Holmes and William Cain, 1893. 8°, 88 pp. *Out of print.*

5. The Forests, Forest Lands, and Forest Products of Eastern North Carolina, by W. W. Ashe, 1894. 8°, 128 pp., 5 pl. *Out of print.*

6. The Timber Trees of North Carolina, by Gifford Pinchot and W. W. Ashe, 1897. 8°, 227 pp., 22 pl. *Out of print.*

7. Forest Fires: Their Destructive Work, Causes and Prevention, by W. W. Ashe, 1895. 8°, 66 pp., 1 pl. *Postage 5 cents.*

8. Water-powers in North Carolina, by George F. Swain, Joseph A. Holmes, and E. W. Myers, 1899. 8°, 362 pp., 16 pl. *Out of print.*

9. Monazite and Monazite Deposits in North Carolina, by Henry B. C. Nitze, 1895. 8°, 47 pp., 5 pl. *Out of print.*

10. Gold Mining in North Carolina and other Appalachian States, by Henry B. C. Nitze and A. J. Wilkins, 1897. 8°, 164 pp., 10 pl. *Out of print.*

11. Corundum and the Basic Magnesian Rocks of Western North Carolina, by J. Volney Lewis, 1895. 8°, 107 pp., 6 pl. *Out of print.*

12. History of the Gems Found in North Carolina, by George Frederick Kunz, 1907. 8°, 60 pp., 15 pl. *Out of print.*

13. Clay Deposits and Clay Industries in North Carolina, by Heinrich Ries, 1897. 8°, 157 pp., 12 pl. *Out of print.*

14. The Cultivation of the Diamond-back Terrapin, by R. E. Coker, 1906. 8°, 67 pp., 23 pl., 2 figs. *Out of print.*

15. Experiments in Oyster Culture in Pamlico Sound, North Carolina, by Robert E. Coker, 1907. 8°, 74 pp., 17 pl., 11 figs. *Postage 10 cents.*

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17. Terracing of Farm Lands, by W. W. Ashe, 1908. 8°, 38 pp., 6 pl., 2 figs. *Postage 4 cents.*

18. Bibliography of North Carolina Geology, Mineralogy, and Geography, with a list of Maps, by Francis Baker Laney and Katherine Hill Wood, 1909. 8°, 428 pp. *Postage 25 cents. Cloth-bound copy, 50 cents extra.*

19. The Tin Deposits of the Carolinas, by Joseph Hyde Pratt and Douglas B. Sterrett, 1905. 8°, 64 pp., 8 figs. *Postage 4 cents.*

20. Water-powers of North Carolina: An Appendix to Bulletin 8, 1910. 8°, 383 pp. *Postage 25 cents.*

21. The Gold Hill Mining District of North Carolina, by Francis Baker Laney, 1910. 8°, 137 pp., 23 pl., 5 figs. *Postage 15 cents. Cloth copies 50 cents extra.*

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23. Forest Conditions in Western North Carolina, by J. S. Holmes, 1911. 8°, 116 pp., 8 pl. *Postage 15 cents.*

24. Loblolly or North Carolina Pine, by W. W. Ashe, Forest Inspector, U. S. Forest Service (and former Forester of the North Carolina Geological and Economic Survey). Prepared in Coöperation with the Forest Service, U. S. Department of Agriculture, 1914. 8°, 176 pp., 27 pl., 5 figs. *Postage 15 cents. Cloth copies 50 cents extra.*

25. Zircon, Monazite, and Other Minerals used in the Production of Chemical Compounds Employed in the Manufacture of Lighting Apparatus, by Joseph Hyde Pratt, Ph.D., 1916. 8°, 120 pp., 3 pl. *Postage 15 cents. Cloth copies 50 cents extra.*

26. A Report on the Virgilina Copper District of North Carolina and Virginia, by F. B. Laney, Ph.D., 1917. 8°, 176 pp., 20 pl., 16 figs., 1 map. *Postage .. cents. In press.*

27. The Altitudes of North Carolina, 1917. 8°, 124 pp. *Postage 20 cents.*

ECONOMIC PAPERS

1. The Maple Sugar Industry in Western North Carolina, by W. W. Ashe, 1897. 8°, 34 pp. *Postage 2 cents.*

2. Recent Road Legislation in North Carolina, by J. A. Holmes. *Out of print.*

3. Talc and Pyrophyllite Deposits in North Carolina, by Joseph Hyde Pratt, 1900. 8°, 29 pp., 2 maps. *Postage 2 cents.*

4. The Mining Industry in North Carolina During 1900, by Joseph Hyde Pratt, 1901. 8°, 36 pp., and map. *Postage 2 cents.*

Takes up in some detail Occurrences of Gold, Silver, Lead and Zinc, Copper, Iron, Manganese, Corundum, Granite, Mica, Talc, Pyrophyllite, Graphite, Kaolin, Gem Minerals, Monazite, Tungsten, Building Stones, and Coal in North Carolina.

5. Road Laws of North Carolina, by J. A. Holmes. *Out of print.*

6. The Mining Industry in North Carolina During 1901, by Joseph Hyde Pratt, 1902. 8°, 102 pp. *Out of print.*

Gives a List of Minerals found in North Carolina; describes the Treatment of Sulphuret Gold Ores, giving localities; takes up the Occurrence of Copper in the Virgilina, Gold Hill, and Ore Knob districts; gives Occurrence and Uses of Corundum; a List of Garnets, describing Localities; the Occurrence, Associated Minerals, Uses and Localities of Mica; the Occurrence of North Carolina Feldspar, with Analyses; an extended description of North Carolina Gems and Gem Minerals; Occurrences of Monazite, Barytes, Ocher; describes and gives Occurrences of Graphite and Coal; describes and gives Occurrences of Building Stones, including Limestone; describes and gives Uses for the various forms of Clay; and under the head of "Other Economic Minerals," describes and gives Occurrences of Chromite, Asbestos, and Zircon.

7. Mining Industry in North Carolina During 1902, by Joseph Hyde Pratt, 1903. 8°, 27 pp. *Out of print.*

8. The Mining Industry in North Carolina During 1903, by Joseph Hyde Pratt, 1904. 8°, 74 pp. *Postage 4 cents.*

Gives description of Mines worked for Gold in 1903; description of Properties worked for Copper during 1903, together with assay of ore from Twin-Edwards Mine; Analyses of Limonite ore from Wilson Mine; the Occurrence of Tin; in some detail the Occurrences of Abrasives; Occurrences of Monazite and Zircon; Occurrences and Varieties of Graphite, giving Methods of Cleaning; Occurrences of Marble and other forms of Limestone; Analyses of Kaolin from Barber Creek, Jackson County, North Carolina.

9. The Mining Industry in North Carolina During 1904, by Joseph Hyde Pratt, 1905. 8°, 95 pp. *Postage 4 cents.*

Gives Mines Producing Gold and Silver during 1903 and 1904 and Sources of the Gold Produced during 1904; describes the mineral Chromite, giving Analyses of Selected Samples of Chromite from Mines in Yancey County; describes Commercial Varieties of Mica, giving the manner in which it occurs in North Carolina, Percentage of Mica in the Dikes, Methods of Mining, Associated Minerals, Localities, Uses; describes the mineral Barytes, giving Method of Cleaning and Preparing Barytes for Market; describes the use of Monazite as used in connection with the Preparation of the Bunsen Burner, and goes into the use of Zircon in connection with the Nernst Lamp, giving a List of the Principal Yttrium Minerals; describes the minerals containing Corundum Gems, Hiddenite and Other Gem Minerals, and gives New Occurrences of these Gems; describes the mineral Graphite and gives new Uses for same.

10. Oyster Culture in North Carolina, by Robert E. Coker, 1905. 8°, 39 pp. *Out of print.*

11. The Mining Industry in North Carolina During 1905, by Joseph Hyde Pratt, 1906. 8°, 95 pp. *Postage 4 cents.*

Describes the mineral Cobalt and the principal minerals that contain Cobalt; Corundum Localities; Monazite and Zircon in considerable detail, giving Analyses of Thorianite; describes Tantalum Minerals and gives description of the Tantalum Lamp; gives brief description of Peat Deposits; the manufacture of Sand-lime Brick; Operations of Concentrating Plant in Black Sand Investigations; gives Laws Relating to Mines, Coal Mines, Mining, Mineral Interest in Land, Phosphate Rock, Marl Beds.

12. Investigations Relative to the Shad Fisheries of North Carolina, by John N. Cobb, 1906. 8°, 74 pp., 8 maps. *Postage 6 cents.*

13. Report of Committee on Fisheries in North Carolina. Compiled by Joseph Hyde Pratt, 1906. 8°, 78 pp. *Out of Print.*

14. The Mining Industry in North Carolina During 1906, by Joseph Hyde Pratt, 1907. 8°, 144 pp., 20 pl., and 5 figs. *Postage 10 cents.*

Under the head of "Recent Changes in Gold Mining in North Carolina," gives methods of mining, describing Log Washers, Square Sets, Cyanide Plants, etc., and detailed descriptions of Gold Deposits and Mines are given; Copper Deposits of Swain County are described; Mica Deposits of Western North Carolina are described, giving Distribution and General Character, General Geology, Occurrence, Associated Minerals, Mining and treatment of Mica, Origin, together with a description of many of the mines; Monazite is taken up in considerable detail as to Location and Occurrence, Geology, including classes of Rocks, Age, Associations, Weathering, method of Mining and Cleaning, description of Monazite in Original Matrix.

15. The Mining Industry in North Carolina During 1907, by Joseph Hyde Pratt, 1908. 8°, 176 pp., 13 pl., and 4 figs. *Postage 15 cents.*

Takes up in detail the Copper and Gold Hill Copper District; a description of the Uses of Monazite and its Associated Minerals; descriptions of Ruby, Emerald, Beryl, Hiddenite, and Amethyst Localities; a detailed description with Analyses of the Principal Mineral Springs of North Carolina; a description of the Peat Formations in North Carolina, together with a detailed account of the Uses of Peat and the Results of an Experiment Conducted by the United States Geological Survey on Peat from Elizabeth City, North Carolina.

16. Report of Convention called by Governor R. B. Glenn to Investigate the Fishing Industries in North Carolina, compiled by Joseph Hyde Pratt, State Geologist, 1908. 8°, 45 pp. *Out of print.*

17. Proceedings of Drainage Convention held at New Bern, North Carolina, September 9, 1908. Compiled by Joseph Hyde Pratt, 1908. 8°, 94 pp. *Out of print.*

18. Proceedings of Second Annual Drainage Convention held at New Bern, North Carolina, November 11 and 12, 1909, compiled by Joseph Hyde Pratt, and containing North Carolina Drainage Law, 1909. 8°, 50 pp. *Out of print.*

19. Forest Fires in North Carolina During 1909, by J. S. Holmes, Forester, 1910. 8°, 52 pp., 9 pl. *Out of print.*

20. Wood-using Industries of North Carolina, by Roger E. Simmons, under the direction of J. S. Holmes and H. S. Sackett, 1910. 8°, 74 pp., 6 pl. *Postage 7 cents.*

21. Proceedings of the Third Annual Drainage Convention, held under Auspices of the North Carolina Drainage Association; and the North Carolina Drainage Law (codified). Compiled by Joseph Hyde Pratt, 1911. 8°, 67 pp., 3 pl. *Out of print.*

22. Forest Fires in North Carolina During 1910, by J. S. Holmes, Forester, 1911. 8°, 48 pp. *Out of print.*

23. Mining Industry in North Carolina During 1908, '09, and '10, by Joseph Hyde Pratt and Miss H. M. Berry, 1911. 8°, 134 pp., 1 pl., 27 figs. *Postage 10 cents. Cloth copies 50 cents extra.*

Gives report on Virgilina Copper District of North Carolina and Virginia, by F. B. Laney; Detailed report on Mica Deposits of North Carolina, by Douglas B. Sterrett; Detailed report on Monazite, by Douglas B. Sterrett; Reports on various Gem Minerals, by Douglas B. Sterrett; Information and Analyses concerning certain Mineral Springs; Extracts from Chance Report of the Dan River and Deep River Coal Fields; Some notes on the Peat Industry, by Professor Charles A. Davis; Extract from report of Arthur Keith on the Nantahala Marble; Description of the manufacture of Sand-lime Brick.

24. Fishing Industry of North Carolina, by Joseph Hyde Pratt, 1911. 8°, 44 pp. *Out of print.*

25. Proceedings of Second Annual Convention of the North Carolina Forestry Association, held at Raleigh, North Carolina, February 21, 1912. Forest Fires in North Carolina During 1911. Suggested Forestry Legislation. Compiled by J. S. Holmes, Forester, 1912. 8°, 71 pp. *Postage 5 cents.*

26. Proceedings of Fourth Annual Drainage Convention, held at Elizabeth City, North Carolina, November 15 and 16, 1911, compiled by Joseph Hyde Pratt, State Geologist, 1912. 8°, 45 pp. *Out of print.*

27. Highway Work in North Carolina, containing a Statistical Report of Road Work during 1911 by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary, 1912. 8°, 145 pp., 11 figs. *Out of print.*

28. Culverts and Small Bridges for Country Roads in North Carolina, by C. R. Thomas and T. F. Hickerson, 1912. 8°, 56 pp., 14 figs., 20 pl. *Postage 10 cents.*

29. Report of the Fisheries Convention held at New Bern, N. C., December 13, 1911, compiled by Joseph Hyde Pratt, State Geologist, together with a Compendium of the Stenographic Notes of the Meetings Held on the two trips taken by the Legislative Fish Committee Appointed by the General Assembly of 1909, and the Legislation Recommended by this Committee, 1912. 8°, 302 pp. *Postage 15 cents.*

30. Proceedings of the Annual Convention of the North Carolina Good Roads Association held at Charlotte, N. C., August 1 and 2, 1912, in Coöperation with the North Carolina Geological and Economic Survey. Compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary, 1912. 8°, 109 pp. *Postage 10 cents.*

31. Proceedings of Fifth Annual Drainage Convention held at Raleigh, N. C., November 26 and 27, 1912. Compiled by Joseph Hyde Pratt, State Geologist. 8°, 56 pp., 6 pl. *Postage 5 cents.*

32. Public Roads are Public Necessities, by Joseph Hyde Pratt, State Geologist, 1913. 8°, 62 pp. *Postage 5 cents.*

33. Forest Fires in North Carolina during 1912 and National and Association Coöperative Fire Control, by J. S. Holmes, Forester, 1913. 8°, 63 pp. *Postage 5 cents.*

34. Mining Industry in North Carolina during 1911-12, by Joseph Hyde Pratt, State Geologist, 1914. 8°, 314 pp., 23 pl., 12 figs. *Postage 15 cents.*

Gives detailed report on Gold Mining in various counties with special report on Metallurgical Processes used at the Iola Mine, by Claud Hafer; description of a Cyanide Mill, by Percy Barbour; the new milling process for treating North Carolina Siliceous Gold Ores at the Montgomery Mine, including a description of the Uwarrie Mining Company's Plant; notes on the Carter Mine, Montgomery County, by Claud Hafer; also a description of the Howie Mine and its mill; a detailed report of the Coggins (Appalachian) Gold Mine, by Joseph Hyde Pratt; a list of gems and gem minerals occurring in the United States; special descriptions of Localities where the Amethyst, Beryl, Emerald, and Quartz Gems Occur as taken from United States Geological Survey Report by Douglas B. Sterrett; a report on the Dan River Coal Field, by R. W. Stone, as reprinted from Bulletin 471-B of the United States Geological Survey; a special report on Graphite, by Edson S. Bastin and reprinted from Mineral Resources of United States for 1912; a special report on Asbestos describing both the Amphibole and Chrysotile varieties; a report on the Mount Airy Granite Quarry; special report on Sand and Gravel, giving Uses, Definitions of Various Sands, etc.; the portion of a Bulletin on Feldspar and Kaolin of the United States Bureau of Mines, which relates to North Carolina, and which takes up in detail Occurrences, Methods of Mining, and Descriptions of Localities of Feldspar and Kaolin mines in North Carolina, prepared by Mr. A. S. Watts. In this Economic Paper are also given the names and addresses of producers of the various minerals during the years covered by the report.

35. Good Roads Days, November 5th and 6th, 1913, compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary. 8°, 102 pp., 11 pl. *Postage 10 cents.*

36. Proceedings of the North Carolina Good Roads Association, held at Morehead City, N. C., July 31st and August 1, 1913. In Coöperation with the North Carolina Geological and Economic Survey.—Statistical Report of Highway Work in North Carolina during 1912. Compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary. 8°, 127 pp., 7 figs. *Out of print.*

37. Forest Fires in North Carolina during 1913 and a Summary of State Forest Fire Prevention in the United States, by J. S. Holmes, Forester, 1914. 8°, 82 pp. *Postage 8 cents.*

38. Forms covering the Organization of Drainage Districts under the North Carolina Drainage Law, Chapter 442, Public Laws of 1909, and Amendments. And Forms for Minutes of Boards of Drainage Commissioners covering the Organization of the Board up to and Including the Issuing of the Drainage Bonds. Compiled by Geo. R. Boyd, Drainage Engineer. 133 pp. *Postage 15 cents.*

39. Proceedings of the Good Roads Institute held at the University of North Carolina, March 17-19, 1914. Held under the auspices of the Departments of Civil and Highway Engineering of the University of North Carolina and The North Carolina Geological and Economic Survey. 8°, 117 pp., 15 figs., 4 pl. *Postage 10 cents.*

40. Forest Fires in North Carolina during 1914 and Forestry Laws of North Carolina, by J. S. Holmes, State Forester, 1915. 8°, 55 pp. *Postage 5 cents.*

41. Proceedings of Seventh Annual Drainage Convention of the North Carolina Drainage Association held at Wilson, North Carolina, November 18 and 19, 1914. Compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary, 1915. 8°, 76 pp., 3 figs. *Postage 5 cents.*

42. Organization of Coöperative Forest-Fire Protective Areas in North Carolina, being the Proceedings of the Special Conference on Forest Fire Protection held as part of the Conference on Forestry and Nature Study, Montreat,

N. C., July 8, 1915. Prepared by J. S. Holmes, State Forester, 1915. 8°, 39 pp. *Postage 4 cents.*

43. Proceedings of the Second Road Institute, held at the University of North Carolina, February 23-27, 1915. Compiled by Joseph Hyde Pratt and Miss H. M. Berry, Secretary, 1916. 8°, 128 pp. *Postage 15 cents.*

44. Highway Work in North Carolina During the Calendar Year Ending December 31, 1914. Compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary, 1916. 8°, 64 pp. *Postage 10 cents.*

45. Proceedings of the Eighth Annual Drainage Convention. Held under the Auspices of the North Carolina Drainage Association and the North Carolina Geological and Economic Survey, Belhaven, N. C., November 29, 30, and December 1, 1915. 8°, 90 pp. *Postage 10 cents.*

46. The Vegetation of Shackleford Bank, by I. W. Lewis, 1917. 8°, 40 pp., 11 plates. *Postage 10 cents.*

47. Proceedings of the Ninth Annual Drainage Convention. Held under the auspices of the North Carolina Drainage Association and the North Carolina Geological and Economic Survey, Greensboro, N. C., November 22 and 23, 1916. ... pp., ... figs. *Postage ... cents.*

VOLUMES

Vol. I. Corundum and the Basic Magnesian Rocks in Western North Carolina, by Joseph Hyde Pratt and J. Volney Lewis, 1905. 8°, 464 pp., 44 pl., 35 figs. *Postage 32 cents. Cloth-bound copy $1 extra.*

Vol. II. Fishes of North Carolina, by H. M. Smith, 1907. 8°, 453 pp., 21 —pl., 188 figs. *Postage 35 cents. Price $1.50.*

Vol. III. The Coastal Plain Deposits of North Carolina, by William Bullock Clark, Benjamin L. Miller, L. W. Stephenson, B. L. Johnson, and Horatio N. Parker, 1912. 8°, 509 pp., 62 pl., 21 figs. *Postage 35 cents.*

Pt. I.—The Physiography and Geology of the Coastal Plain of North Carolina, by Wm. Bullock Clark, Benjamin L. Miller, and L. W. Stephenson.
Pt. II.—The water resources of the Coastal Plain of North Carolina, by L. W. Stephenson and B. L. Johnson.

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BIENNIAL REPORTS

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Biennial Report, 1907-1908, Joseph Hyde Pratt, State Geologist, 1908. 8°, 60 pp., 2 pl. *Postage 5 cents.*

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Biennial Report, 1909-1910, Joseph Hyde Pratt, State Geologist, 1911. 8°, 152 pp. *Postage 10 cents.*

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Biennial Report, 1911-1912, Joseph Hyde Pratt, State Geologist, 1913. 8°, 118 pp. *Postage 7 cents.*

Administrative report, and contains reports on method of construction and estimate of cost of road improvement in Stantonsburg Township, Wilson County; report on road conditions in Lee County; report on preliminary location of section of Spartanburg-Hendersonville Highway between Tryon and Tuxedo; report of road work done by United States Office of Public Roads during biennial period; experiments with glutrin on the sand-clay road; report on Central Highway, giving Act establishing and report of trip over the Highway; suggested road legislation; report on the Asheville City watershed; report on the Struan property at Arden, Buncombe County; report on the woodlands on the farm of Dr. J. W. Kilgore, Iredell County; report on examination of the woodlands on the Berry place, Orange County; report on the forest property of Miss Julia A. Thorns, Ashboro, Randolph County; report on the examination of the forest lands of the Butters Lumber Company, Columbus County; proposed forestry legislation; swamp lands and drainage, giving drainage districts; suggested drainage legislation; proposed Fisheries Commission Bill.

Biennial Report, 1913-1914, Joseph Hyde Pratt, State Geologist, 1915. 8°, 165 pp. *Postage 10 cents.*

Administrative report, and contains reports on the work of the State convicts on Hickory Nut Gap Road, Henderson County, and on the link of the Central Highway in Madison County which is being constructed with State convicts; report on road work accomplished by the State Survey and by the United States Office of Public Roads during biennial period; suggested road legislation; a forestry policy for North Carolina; report on investigation. Timber supply of North Carolina; reports on the examination of certain forest lands in

Halifax County; report on the ash in North Carolina; report on the spruce forests of Mount Mitchell; report on the forest fire conditions in the northeastern States, by J. S. Holmes. Report on the work of the United States Forest Service in North Carolina in connection with the purchase of forest reserves and their protection; timber tests, including strength of timber, preservation of timber, timber suitable to produce pulp, distillation of certain woods and drying certain woods; suggested forestry legislation; report on the swamp lands and their drainage in North Carolina; suggested drainage legislation; report on magnetic observations made during biennial period; report on the economic value of the fisheries of North Carolina; report on the survey made in Albemarle, Croatan, and Pamlico sounds by the Coast and Geodetic Survey; suggested fisheries legislation.

Biennial Report, 1915-1916, Joseph Hyde Pratt, State Geologist, 1917. 8°, 202 pp. *Postage 20 cents.*

Administrative Report.

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